Portland International Airport

Capacity Enhancement Plan

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October 2001

Prepared jointly by the US Department of Transportation, Federal Aviation Administration, the Port of Portland, the airlines, the Oregon Air National Guard, and general aviation serving Portland, Oregon.

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Summary

The Portland metropolitan area has a healthy, diverse economy with a broad base of manufacturing, distribution, wholesale and retail trade, regional government, and business services. The region's diversity helps make the business environment stable, reducing the effects of adverse economic cycles.

High technology is a vital part of Portland's economy and a key component of its continuing viability in the future. Currently, Portland has over 1,000 high tech companies and that number continues to increase. From 1990 to 1999, Portland's high tech manufacturing employment grew by 40 percent.

Manufacturing is one of the largest sectors for this state's economy, employing approximately 16 percent of the work force in 1999. This sector includes: machinery, electronics, metals, transportation equipment, lumber and wood products. The Portland metropolitan area accounts for nearly 75 percent of Oregon's high tech manufacturing jobs and almost one-fifth of the state's total manufacturing.

In support of this economic base the strategic plan for the Port of Portland, includes, but are not limited to:

- Securing access to the international and domestic passenger and cargo markets required to serve the region's citizens and businesses.
- Providing the infrastructure necessary to meet the region's demands for marine and aviation operations.

With a strategically favorable location that offers easy access to west coast markets and 105 domestic cities, Portland's economy is closely linked to the nation and the Far East. Forecasts indicate that over the next twenty years: [1]

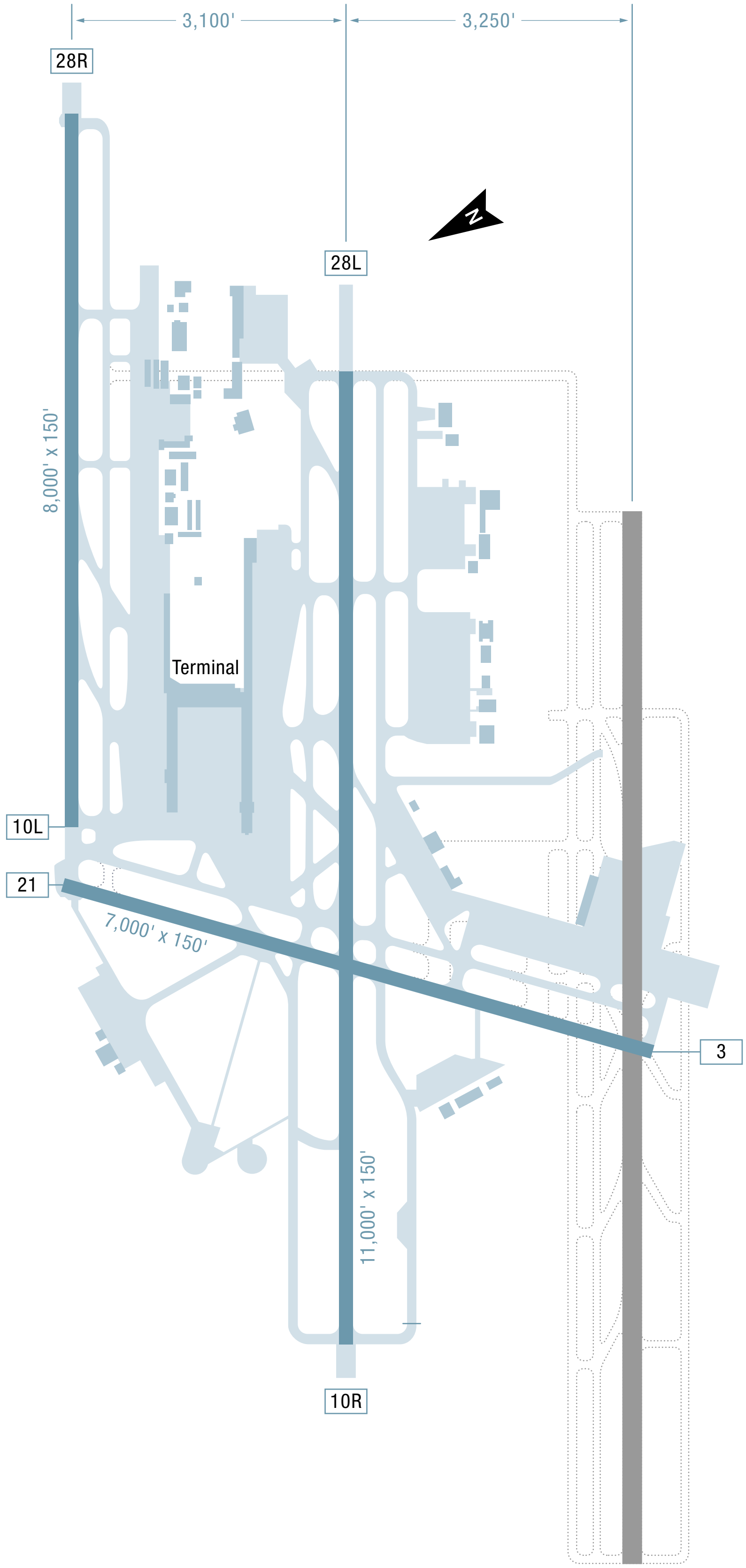
- The number of airline passengers will double.
- Air cargo tonnage will nearly triple.

As a result of this forecasted growth, the initial Portland International Airport (PDX) Capacity Enhancement Plan was completed in 1996 to identify and evaluate alternative means to enhance existing airport and airspace capacity. The current design team was formed in 1999 to provide an updated capacity study to assess the technical merits of potential airfield expansion as presented in the Portland Master Plan update of September 2000 (Figure 1). The PDX Capacity Team identified and assessed various alternatives that, if implemented, would increase PDX's capacity, improve operational efficiency, and reduce aircraft delays.

This technical study identifies the operational benefits or delay-related cost savings of capacity enhancement alternatives. It does not result in decisions, recommendations, or policies nor, establish procedures. Additional studies will be needed to assess environmental, social economical, or political issues associated with these alternatives.

1 ***Transporting Our Region Into The 21st Century,*** The Port of Portland's Strategic Plan

Figure 1. Portland Master Plan, September 2000



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The following alternatives identified by the Capacity Team were simulated using a standard computer model developed by the FAA:

1. Third Parallel Runway – All Aircraft.
2. Third Parallel Runway – Prop-Only.
3. N/S Taxiway Connecting East Ends of the Existing Parallel Runways.
4. Simultaneous (Independent) CAT I Approaches to the Existing Parallel Runways.
5. No Departure Noise Restrictions for Turboprops and Biz Jets in Both Flow Directions.
6. No Departure Noise Restrictions for Any Aircraft.

Different levels of activities were chosen to represent growth in aircraft operations in order to compare the merits of each action. These annual activity levels are referred to throughout this report as:

- Baseline 322,000 operations
- Future 1 (F1) 484,000 operations
- Future 2 (F2) 620,000 operations

Figure 2 illustrates the average delay in minutes per aircraft operations. In the Basecase, the average delay of 1.4 minutes per operations at the Baseline activity level will increase to 6.4 minutes by Future 1, and to 42.1 minutes by Future 2.

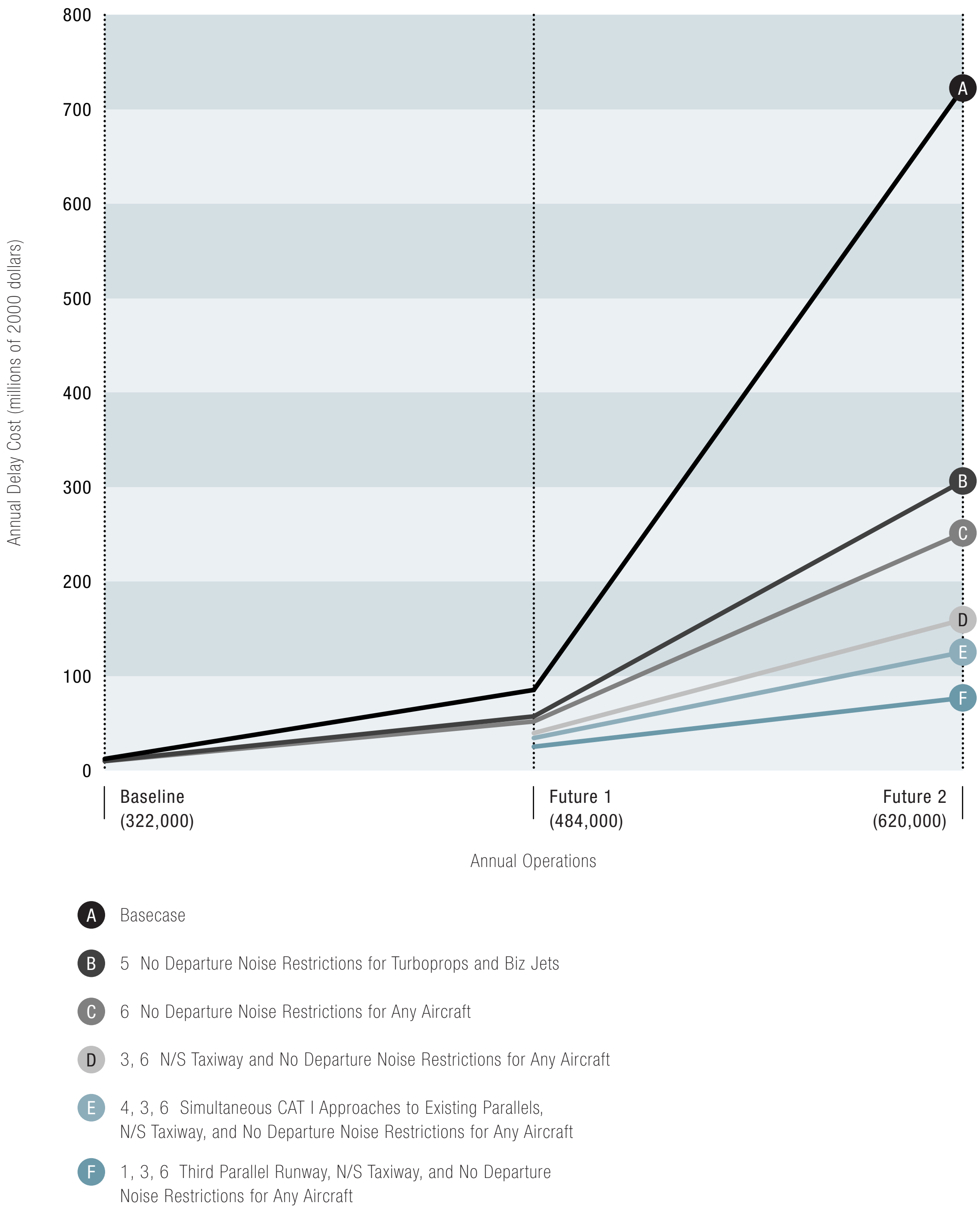
Figure 2. Average Delay Per Operation – Minutes

		Estimated Average Delay per Operation (in minutes)		
		Baseline 322,000	**Future 1 484,000**	**Future 2 620,000**
Basecase				
With Existing Departure Noise Restrictions		1.4	6.4	42.1
Airfield and Operational Alternatives				
1, 3, 6	Third Parallel Runway, N/S Taxiway, and No Departure Noise Restrictions for Any Aircraft	**	1.9	4.5
3, 6	N/S Taxiway and No Departure Noise Restrictions for Any Aircraft	**	3.0	9.3
4, 3, 6	Simultaneous CAT I Approaches to Existing Parallels, N/S Taxiway, and No Departure Noise Restrictions for Any Aircraft	**	2.6	7.3
5	No Departure Noise Restrictions for Turboprops and Biz Jets	1.1	4.3	17.9
6	No Departure Noise Restrictions for Any Aircraft	1.1	3.9	14.7

** Alternatives were not simulated at these activity levels.

Figure 3 shows the annual delay costs for the simulated alternatives at PDX. Annual delay costs for the Basecase (in year 2000 dollars) will increase from $12.3 million at the Baseline activity level, to $85.3 by Future 1, and $722.5 by Future 2.

Figure 3. PDX Annual Delay Cost



Note: Alternative 2 Not Simulated

Figure 4 shows the Capacity Enhancement Alternatives evaluated by the Design Team and the estimated annual delay savings for each alternative at various demand levels. The Baseline, Future 1, and Future 2 activity levels correspond to annual aircraft operations of 322,000, 484,000, and 620,000, respectively.

Figure 4. Capacity Enhancement Alternatives and Annual Delay Savings

		Estimated Annual Delay Costs (in hours and millions of 2000 dollars)					
		Baseline 322,000		**Future 1 484,000**		**Future 2 620,000**	
Basecase							
With Existing Departure Noise Restrictions		7,409	$12.3	51,376	$85.3	435,257	$722.5

		Estimated Annual Delay Savings (in hours and millions of 2000 dollars)					
		Baseline 322,000		**Future 1 484,000**		**Future 2 620,000**	
Airfield and Operational Alternatives							
1, 3, 6	Third Parallel Runway, N/S Taxiway, and No Departure Noise Restrictions for Any Aircraft	**		36,184	$60.1	388,954	$645.7
	Savings Over Combined Alternatives 3 and 6			*8,665*	*$14.4*	*49,876*	*$82.8*
	Savings Over Combined Alternatives 4, 3, and 6			*5,516*	*$9.2*	*29,236*	*$48.5*
3, 6	N/S Taxiway and No Departure Noise Restrictions for Any Aircraft	**		27,519	$45.7	339,078	$562.9
	Savings Over Alternative 6			*7,392*	*$12.3*	*55,326*	*$91.8*
4, 3, 6	Simultaneous CAT I Approaches to Existing Parallels, N/S Taxiway, and No Departure Noise Restrictions for Any Aircraft	**		30,668	$50.9	359,718	$597.1
	Savings Over Alternative 6			*10,541*	*$17.5*	*75,966*	*$126.1*
	Savings Over Combined Alternatives 3 and 6			*3,149*	*$5.2*	*20,640*	*$34.3*
5	No Departure Noise Restrictions for Turboprops and Biz Jets	1,318	$2.2	16,865	$28.0	250,629	$416.0
6	No Departure Noise Restrictions for Any Aircraft	1,450	$2.4	20,127	$33.4	283,752	$471.0
	Savings Over Alternative 5	*132*	*$0.2*	*3,262*	*$5.4*	*33,123*	*$55.0*

** Alternatives were not simulated at these activity levels.

Section 1 – Background

General

The Office of System Capacity (ASC) was established to identify and evaluate initiatives that have the potential to increase capacity, so that current and projected levels of demand can be accommodated with minimum delay and without compromising safety or the environment.

In 1998, approximately 306,000 flights nationwide were delayed 15 minutes or more, an increase of nearly 25 percent from 1997. The challenge for the air transportation industry in the 21st century is to enhance existing airport and airspace capacity and to develop new facilities to keep pace with future demand. While environmental, financial, and other constraints continue to restrict the development of new airport facilities in the US, an increased emphasis has been placed on the re-development and expansion of existing airport facilities.

Portland International Airport

Portland International Airport is the 33rd busiest airport in the country when ranked by passenger enplanements.[2] In the past decade, PDX has been one of the nation's fastest growing airports. Total passengers at PDX rose from 6.4 million in 1989 to 13.4 million in 1999, an increase of 109 percent. PDX's total aircraft operations (takeoffs and landings) reached 322,000 in 1999, an increase of 21 percent over the 267,000 aircraft operations the airport handled in 1989. PDX's growth is evidenced by recent the passenger traffic totals of 12.7 million in 1998 and 13.4 million in 1999, which was an increase of 5 percent.

Portland International Airport is owned and operated by the Port of Portland. The airport is located four miles northeast of downtown Portland on approximately 3,229 acres of land primarily serving five counties: four counties in northwest Oregon and one county in southwest Washington. The airfield has three runways:

- Runway 10L/28R is 8,000 feet long and 150 feet wide.
- Runway 10R/28L is 11,000 feet long and 150 feet wide.
- Runway 3/21 is 7,000 feet long and 150 feet wide.

Portland Airport Capacity Design Team

In 1999, a second Capacity Team for Portland International Airport was formed. This PDX Capacity Team was created to examine the technical issues focusing on delay savings and capacity enhancing alternatives. Such issues include, but are not limited to, delay savings and operational procedures. The Team identified and assessed various actions to determine their merit, if any, in increasing capacity and reducing aircraft delays. The outcome of this effort is the technical viability of several alternatives, which may be used by decision-makers at some future date.

The development alternatives contained in this report are not time dependent. That is, this report has established benchmarks for development based upon traffic levels and not upon any definitive time schedule, since actual growth can vary from projections. As a result, the report should retain its validity until the highest traffic level is attained regardless of the actual dates associated with the development.

A Baseline benchmark of 322,000 aircraft operations (takeoffs and landings) was established based on the annual traffic level for 1999. Two future traffic levels, Future 1 and Future 2, were established at 484,000, and 620,000 annual aircraft operations respectively, based on PDX's low and high operations forecasts contained in their current Master Plan. The Capacity Team concurred with those values based on the potential traffic growth at Portland International. If no alternatives are implemented at PDX, annual delay levels and delay costs are expected to increase from an estimated 7,409 hours and $12.3 million at the Baseline activity level to 51,376 hours and $85.3 million by the Future 1 activity level, and 435,257 hours and $722.5 million by Future 2.

The alternatives evaluated by the Capacity Team are delineated in Figure 2 and described in some detail in Section 2, Capacity Enhancement Alternatives.

Objectives

The primary goal of the Capacity Team was two-fold. First, it was to identify and evaluate technical challenges associated with the development of a third parallel runway. Second, it was to determine potential benefits a new parallel runway would have on increasing airport capacity and reducing aircraft delays. To achieve these objectives, the Capacity Team:

- Assessed the current airport capacity.
- Evaluated capacity and delay benefits of alternative air traffic control (ATC) procedures, navigational alternatives, airfield development, and operational alternatives.
- Evaluated existing constraints due to noise restrictions.

Scope

The Capacity Team limited its analyses to the runway and airspace impacts, specifically, aircraft activity within the terminal area airspace. This study did not examine airfield issues such as taxiway configurations. Nor did the study address environmental, socio-economic, or political issues regarding airport development. These issues are addressed during traditional airport planning studies and the environmental review process using the data generated by this Study.

Methodology

The Capacity Team, which included representatives from the FAA, the Port of Portland, and various aviation industry groups (see Appendix A), met periodically to review, coordinate, and consider proposed capacity alternatives.

Alternatives that were considered practicable were developed into experiments that could be tested by simulation modeling. The Capacity Team calibrated the data used as input for the simulation modeling and analysis and reviewed the interpretation of the simulation results. The data, assumptions, alternatives, and experiments were continually re-evaluated and modified where necessary as the study progressed.

Initial work consisted of gathering data and formulating assumptions required for the capacity and delay analysis and modeling. Where possible, assumptions were based on actual field observations at PDX. Proposed alternatives were analyzed in relation to current and future demands and were simulated using an FAA computer model, the Airfield Delay Simulation Model (ADSIM). Appendix B briefly explains the model.

The simulation model considered air traffic control procedures, construction of a third parallel runway and a North/South taxiway, and traffic demands. Airfield configurations were prepared from present and proposed airport layout plans. Various configurations were evaluated to assess the delay savings benefit of projected alternatives. Air traffic control procedures and system alternatives determined the aircraft separations to be used for the simulations under both visual flight rules (VFR) and instrument flight rules (IFR).

Aircraft fleet mix and schedule assumptions were derived from Official Airline Guide (OAG) data, historical data, and Capacity Team inputs. Aircraft volume, mix, and peaking characteristics were considered for each of the three different demand levels (Baseline, Future 1, and Future 2). From this, annual delay estimates were determined based on implementing various alternatives. These estimates took into account historic variations in runway configuration, weather, and demand. The annual delay estimates for each configuration were then compared to identify delay reductions resulting from the alternatives. Following the evaluation, the Capacity Team developed a set of alternatives for consideration.

The total delay costs are calculated assuming there are no cancellations or deviations of scheduled flights during periods of high delays, which typically occur in IMC conditions. In reality, flights are cancelled when delays are high. The costs of cancelled flights include: passenger costs; hotel costs; re-issued tickets; disruptions to the schedule and bank integrity; equipment; and crew re-positioning and re-scheduling. The actual delay costs of cancelled flights are very difficult to measure because most of the information is proprietary, and the costs of cancellations and deviations vary greatly between airlines. Therefore, the annual delays are calculated without deviation from the full schedule.

Section 2 – Capacity Enhancement Alternatives

The PDX Capacity Enhancement Plan was first published in 1996. The current design team was formed to provide an update to assess the technical merits of potential airfield expansion. The potential alternatives are grouped as follows:

- Airfield Alternatives
- Operational Alternatives

Figure 5 presents the Capacity Enhancement Alternatives that the Design Team considered during the study.

Figure 5. Capacity Enhancement Alternatives Studied

Airfield Alternatives	
1	Third Parallel Runway – All Aircraft
2	Third Parallel Runway – Prop-Only
3	N/S Taxiway Connecting East Ends of the Existing Parallel Runways
Operational Alternatives	
4	Simultaneous (Independent) CAT I Approaches to the Existing Parallel Runways
5	No Departure Noise Restrictions for Turboprops and Biz Jets in Both Flow Directions
6	No Departure Noise Restrictions for Any Aircraft

Airfield Alternatives

1. Third Parallel Runway – All Aircraft

The capacity of the existing airfield is limited by the inability to conduct simultaneous independent approaches under IMC conditions. This new parallel runway, which is 3,250 feet south of the existing Runway 10R/28L, is the only airfield alternative that could provide the necessary additional capacity to meet demand beyond the year 2020 forecast in the current PDX master plan. The runway would permit three simultaneous independent arrival streams under VMC and two simultaneous independent arrival streams under IMC conditions. Without existing noise restrictions, the new runway would permit three independent departure streams.

The estimated 2000 construction cost	$292.6 million

Combined Savings of Alternatives 1, 3, and 6

The combined annual delay savings for Alternatives 1, 3, and 6 would be 36,184 hours or $60.1 million at Future 1; and 388,954 hours or $645.7 million at Future 2.

The savings of these alternatives over Combined Alternatives 3 and 6 would be 8,665 hours or $14.4 million at Future 1; and 49,876 hours or $82.8 million at Future 2.

The savings of these alternatives over Combined Alternatives 3, 4, and 6 would be 5,516 hours or $9.2 million at Future 1; and 29,26 hours or $48.5 million at Future 2.

2. Third Parallel Runway – Prop-Only

A parallel runway, which is restricted to props, would provide limited benefit. In VMC conditions, the three runways would have independent approaches. In IMC conditions, the two outer runways would have independent approaches, and the center runway would have staggered approaches dependent to each of the outer runways.

With a prop-only runway, the greatest benefit would occur if turboprop and jet activity levels were similar. Since the majority of the PDX flights are jets, a prop-only runway would virtually eliminate the potential for independent approaches in IMC or VMC. Furthermore, as demand increases and regional jets replace turboprop aircraft, any benefits of a prop-only runway would decline. Therefore, the Design Team did not consider a prop-only runway to be a reasonable alternative.

3. N/S Taxiway Connecting East Ends of the Existing Parallel Runways

The new taxiway would provide PDX with a second crossfield taxiway between the East end of Runways 10R/28L and 10L/28R. It would reduce taxi times for arrivals and departures. The taxiway would also provide a more direct routing for aircraft taxiing between the north and south apron edge taxiways.

In the West Flow, the taxiway would give controllers more flexibility in departing aircraft. Northbound departures gated at concourses A, B, and C would be able to use Runway 28R without taxi conflict from arrivals to the same runway. In the East flow, the taxiway would benefit aircraft arriving on Runway 10L destined for gates located at concourses A, B, and C, and in the future, the East Concourse, by reducing taxi time and ground congestion. The taxiway would also benefit departures in the East Flow because southbound departures from concourses D and E could be directed to Runway 10R. This is due to reduced ground congestion enabled by Runway 10L arrivals using the North/South Taxiway.

With the existing noise restrictions, the North/South Taxiway would significantly increase flexibility in moving aircraft on the ground and greatly improve traffic flow in both flow directions. With no noise abatement restrictions, departure runways could be assigned based on direction of flight rather than gate locations, especially in the West Flow.

The estimated 2000 construction cost	$169.1 million

Combined Savings of Alternatives 3 and 6

The combined annual delay savings for Alternatives 3 and 6 would be 27,519 hours or $45.7 million at Future 1; and 339,078 or $562.9 million at Future 2.

The savings of these alternatives over Alternative 6 would be 7,392 hours or $12.3 million at Future 1; and 55,326 hours or $91.8 million at Future 2.

Operational Alternatives

4. Simultaneous (Independent) CAT I Approaches to the Existing Parallel Runways

Currently, PDX conducts staggered CAT I approaches to the parallel runways. The ability to perform simultaneous independent CAT I parallel approaches would significantly increase PDX's capacity, improve operational efficiency and flexibility of controllers, and reduce controller workload.

To conduct simultaneous independent CAT I approaches to two parallel runways, without any type of electronic enhancement to the aircraft or air traffic facilities, the FAA requires the runway centerline separation to be at least 4,300 feet. Recent technology/equipment upgrades, such as the Precision Runway Monitor (PRM), permit simultaneous independent approaches to parallel runways with a minimum centerline separation of 3,400 feet. However, the separation at PDX is 3,100 feet and does not permit this type of operation.

Technologies being considered for the future includes multi-lateration, ADS-B (Automatic Dependent Surveillance-Broadcast), and Required Navigation Performance (RNP). If these or other new technologies enable PDX to conduct simultaneous CAT I approaches, they would increase capacity and improve operational efficiency.

Combined Savings of Alternative 4, 3, and 6

The combined annual delay savings for Alternatives 4, 3, and 6 would be 30,668 hours or $50.9 million at Future 1; and 359,718 hours or $597.1 million at Future 2.

The savings of these alternatives over Alternatives 6 would be 10,541 hours or $17.5 million at Future 1; and 75,966 hours or $126.1 million at Future 2.

The savings of these alternatives over Combined Alternatives 3 and 6 would be 3,149 hours or $5.2 million at Future 1; and 20,640 hours or $34.3 million at Future 2.

5. No Departure Noise Restrictions for Turboprops and Biz Jets

Current noise abatement procedures for turboprops allow immediate south divergent turns in both flow directions. Removing the departure noise restrictions for turboprops and biz jets would enable the aircraft to depart more efficiently. North and South divergent turns would allow the tower to turn turboprops and biz jet departures in a manner that would expedite departure situations. Based on the current fleet mix at Portland, there is a large number of aircraft that would be able to take advantage of this new procedure. Any increase in the departure rate would improve efficiency for the entire airport. Departures leaving sooner would reduce the number of aircraft waiting for takeoff and subsequent taxiway congestion.

Annual delay savings would be 1,318 hours or $ 2.2 million at the Baseline activity level; 16,865 hours or $ 28.0 million at Future 1; and 250,629 hours or $ 416.0 at Future 2.

6. No Departure Noise Restrictions for Any Aircraft

Current noise abatement restrictions place all heavy and large turbojet departures on a single departure route regardless of the departing runway or destination. This forces the tower to wait for the required IFR separation before departing successive jet aircraft. Implementing this alternative would enable the tower to turn all aircraft using the divergent turn rule. This would streamline the departure procedures, reduce the tower controller's workload, reduce departure delays, and allow for the most expeditious departure scenario at Portland.

Annual delay savings would be 1,450 hours or $ 2.4 million at the Baseline activity level; 20,127 hours or $ 33.4 million at Future 1; and 283,752 hours or $ 471.0 at Future 2.

The savings of this alternative over Alternative 5 of 132 hours or $ 0.2 million at the Baseline activity level; 3,262 hours or $ 5.4 million at Future 1; and 33,123 hours or $ 55.0 million at Future 2.

Section 3 – Summary of Technical Studies

Overview

The PDX Capacity Team evaluated the efficiency of the existing airfield and the proposed future configurations. A brief description of the computer model and methodology used can be found in Appendix B. The model inputs reflected the operating environment at PDX. The potential benefits of various alternatives were determined by examining airfield capacity, airfield demand, and average aircraft delays.

The cost of the 1999 PDX Fleet Mix was computed at $1,660 per hour by the FAA Technical Center and used to determine annual delay costs and savings. The fleet mix cost represents the CY 2000 (1st quarter) direct operating costs of the airlines serving PDX. The costs include: cockpit crew; fuel and oil; rentals; insurance; taxes; total flying operations; maintenance; and depreciation. They do not consider intangible factors such as lost passenger time or disruption to airline schedules.

Daily operations corresponding to an average busy day in the peak month were used for each of the forecast periods. The Airfield Delay Simulation Model (ADSIM) was used to determine aircraft delays during peak periods. Delays were calculated for current and future conditions. Daily delays were annualized to measure the potential economic benefits of the proposed alternatives. The annualized delays provided a basis for comparing the benefits of the proposed changes. The cost of a particular alternative was measured against its annual delay savings. The comparison indicated which alternatives would be the most effective.

For expected increases in demand, a combination of alternatives can be implemented to allow airfield capacity to increase while aircraft delays are minimized.

Figure 6 shows airfield weather conditions and runway utilization used for simulation.

Figure 6. Runway Utilization – Simulated

Weather	VFR 1	VFR 2	IFR 1	
Minima:	Visual	< VIS and ≥ IFR	CAT I	All Weather
Ceiling:	3,500'	2,000'	200'	
Visibility:	10 miles	5 miles	0.5 miles	
East Flow (10L/10R)	35.3%	9.2%	7.8%	52.3%
West Flow (28L/28R)	39.1%	5.0%	3.6%	47.7%
Total	**74.4%**	**14.2%**	**11.4%**	**100.0%**

Note: IFR 1 conditions usually occur in full days. Because of the climate and the terrain along the Columbia River, PDX remains in IFR 1 conditions most of the day. Therefore, the Design Team simulated full days of IFR 1 conditions. The Team agreed that only VFR1,VFR2, and IFR1 conditions would be simulated due to the nature of the proposed alternatives. Figure 6 represents the conditions modeled. VFR1 and VFR2 are VMC. IFR1 is IMC.

Figure 7 depicts historical runway utilization and weather conditions.

Figure 7. Runway Utilization – Historical

Weather	VFR 1	VFR 2	IFR 1	IFR 2	IFR 3	
Minima:	Visual	< VIS and ≥ IFR	CAT I	CAT II	CAT III	All Weather
Ceiling:	3,500'	2,000'	200'	100'		
Visibility:	10 miles	5 miles	0.5 miles	0.25 miles	0.125 miles	
East Flow (10L/10R)	34.7%	9.1%	7.7%	0.6%	1.1%	53.2%
West Flow (28L/28R)	38.4%	4.9%	3.5%	0.0%	0.0%	46.8%
Total	**73.1%**	**14.0%**	**11.2%**	**0.6%**	**1.1%**	**100.0%**

Note: Figure 7 depicts historical PDX data tabulated from 10 years of Surface Airways Hourly Data (TD-1440) for 1/1/79 through 12/31/88, from the National Climatic Data Center, Asheville, NC.

Figure 8 shows the aircraft approach speeds used for simulation.

Figure 8. Aircraft Approach Speeds

Aircraft Class	Aircraft Types	VFR/IFR (Knots)
Small	Small Twin and Single Engine Props	110
Small+	Small Commuters/Biz Jets (e.g., E120, LR31)	130
Large Turboprop	Large Turboprops (e.g., DH8)	130
Large Jet	Large Jets/ Regional Jets (e.g., B737, B727, CRJ)	140
757	B757	140
Heavy	Widebody Aircraft	155

Note: The aircraft classes were based on 1999 FAA separation standards.

Figure 9 depicts the daily fleet mix by aircraft class for the aircraft operating at PDX at each of the three demand levels.

Figure 9. Aircraft Daily Fleet Mix by Aircraft Class

Aircraft Class	Aircraft Types	Baseline (322,000)	Future 1 (484,000)	Future 2 (620,000)
Small	Small Twin and Single Engine Props	116 (11.5%)	152 (10.1%)	174 (9.0%)
Small+	Small Commuters/Biz Jets (e.g., E120, LR31)	148 (14.7%)	212 (14.0%)	261 (13.5%)
Large Turboprop	Large Turboprops (e.g., DH8)	177 (17.6%)	274 (18.1%)	360 (18.6%)
Large Jet	Large Jets/ Regional Jets (e.g., B737, B727, CRJ)	466 (46.3%)	720 (47.6%)	940 (48.5%)
757	B757	52 (5.2%)	80 (5.3%)	106 (5.5%)
Heavy	Widebody Aircraft	47 (4.7%)	74 (4.9%)	97 (5.0%)

Note: For Figures 8 and 9 aircraft classes were based on 1999 FAA separation standards.

Figure 10 illustrates the hourly profile of daily demand for the Baseline activity level. For comparison, it also includes a curve that depicts the profile of daily operations for the Future 1 and Future 2 activity levels.

Figure 10. Profile of Daily Demand – Hourly Distribution

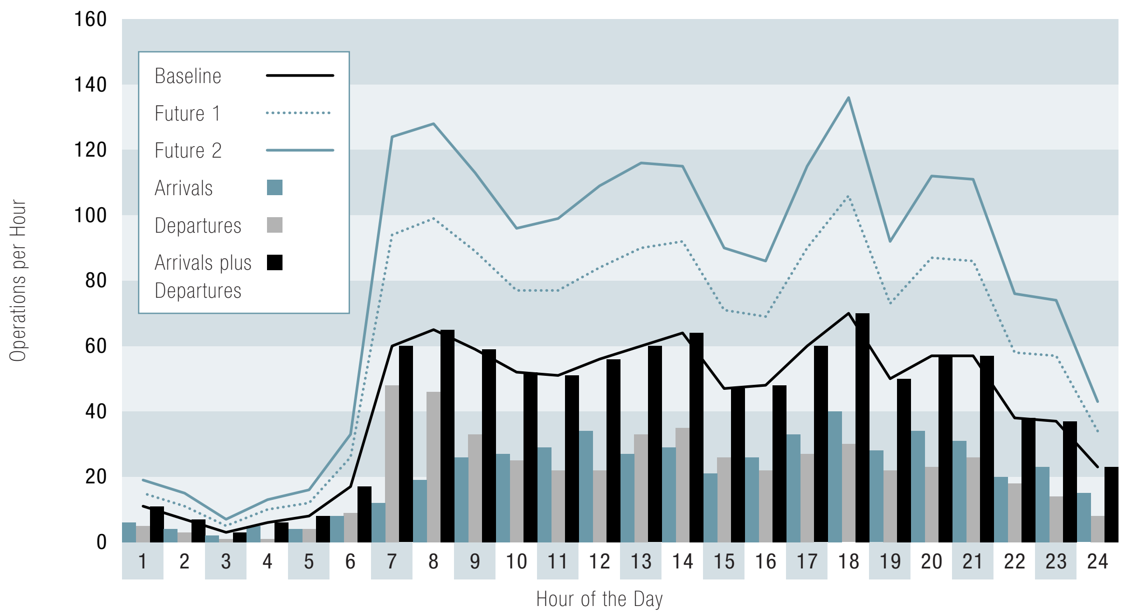
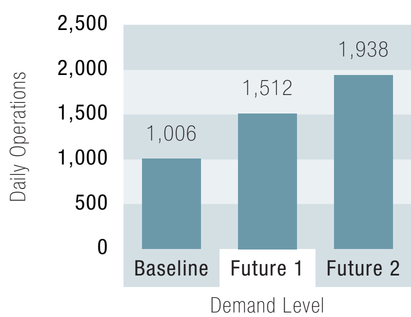


Figure 11 illustrates the average-day, peak-month demand levels at PDX for each of the three annual activity levels used in the study.

Figure 11. Airfield Demand Levels



	Annual Operations	Daily Operations	Equivalent Days
Baseline	322,000	1,006	320
Future 1	484,000	1,512	320
Future 2	620,000	1,938	320

Note: Baseline, Future 1, and Future 2. The number of equivalent days is determined by dividing the number of annual operations by the number of daily operations. To capture the costs associated with flights that are cancelled when the weather deteriorates and delays increase, the Design Team simulated a full schedule in IMC, as well as in VMC.

Figure 12 depicts the annual operations for each activity level by aircraft category.

Figure 12. Annual Operations by Aircraft Category

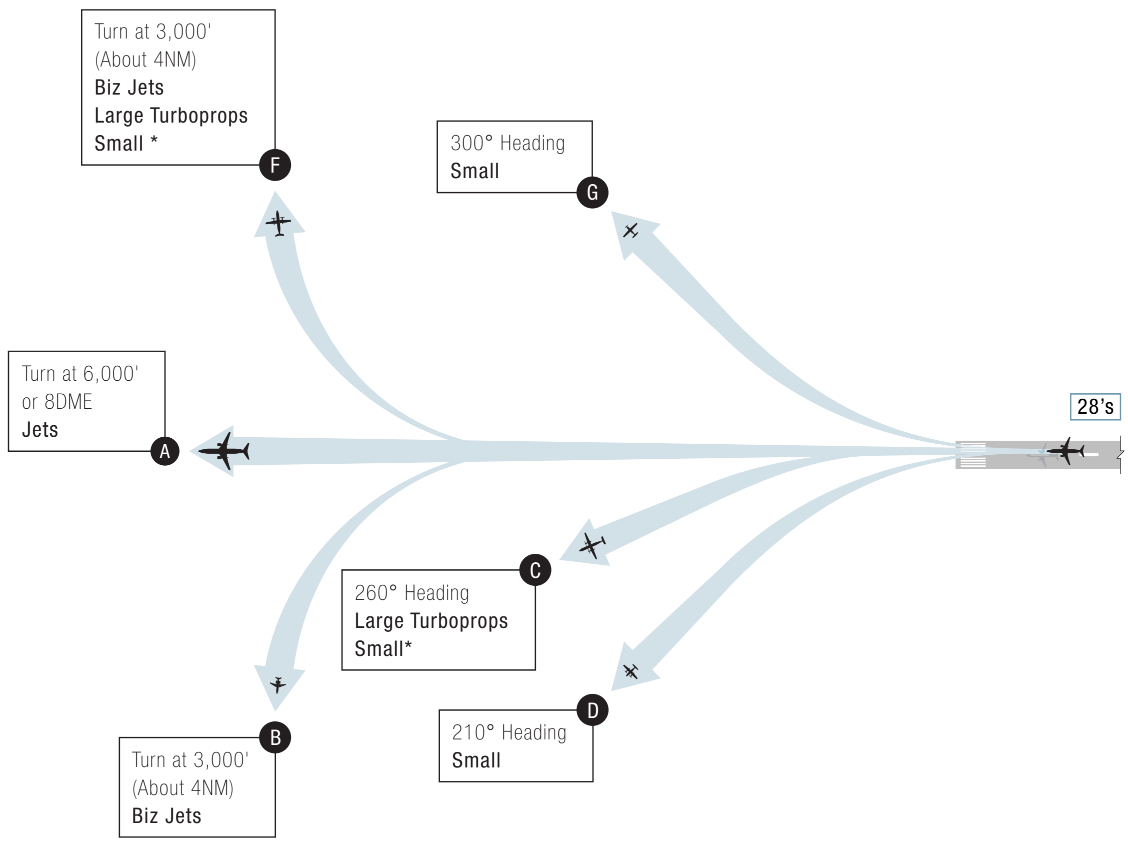
	Commercial		General Aviation		Military		Total	
Baseline	275,000	(85.4%)	38,000	(11.8%)	9,000	(2.8%)	**322,000**	**(100.0%)**
Future 1	429,000	(88.6%)	45,000	(9.3%)	10,000	(2.1%)	**484,000**	**(100.0%)**
Future 2	565,000	(91.1%)	45,000	(7.3%)	10,000	(1.6%)	**620,000**	**(100.0%)**

Figure 13 illustrates the ATC procedures required to implement the departure noise restrictions in the West Flow, when departing on runway to 28L/28R.

Figure 13. Portland Departure Noise Procedures – West Flow

The following refers to the chart below:

B | C | D	Totally Independent with Respect to Noise
A | C | D	Totally Independent with Respect to Noise
C | D | G	Independent of Everyone with Respect to Noise
A South | A North	Full Noise Dependency
A | B	Noise Dependent up to 3,000' (About 4NM from West End of Runway) (Jet/Turbine = 1 minute, Turbine/Jet = 2 minutes)
A | F	Noise Dependent up to 3,000' (About 4NM from West End of Runway) (Jet/Turbine = 1 minute, Turbine/Jet = 2 minutes)
B | F	Noise Dependent up to 3,000' (About 4NM from West End of Runway) (Jet/Turbine = 1 minute, Turbine/Jet = 2 minutes)



West Flow
There are no departure fix restrictions for 2 dissimilar jets going to the same exit fix at the center. *Updated 12/94.*

VFR Flight Plan
Small aircraft can do an immediate turn onto any of several departure paths. *Updated 12/94.*

Notes:

Assume all Biz Jets are quiet because most are quiet.

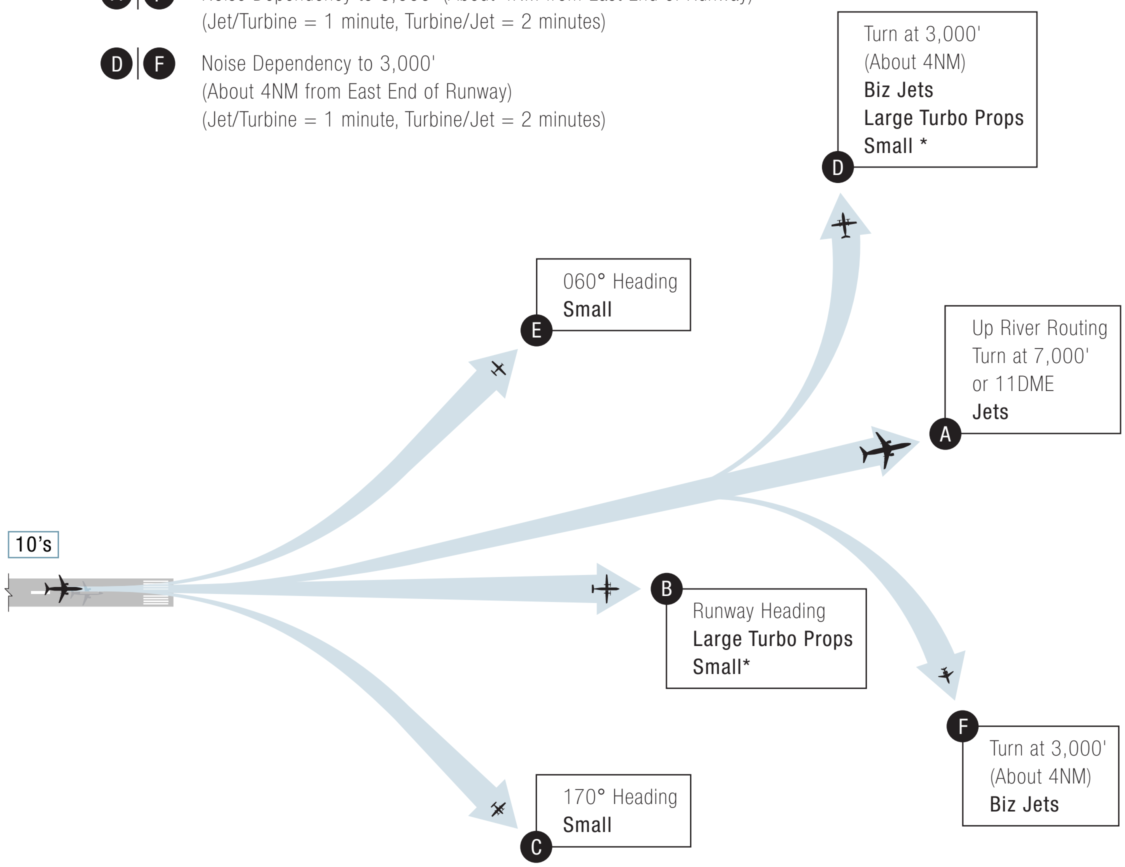
Headings for Southbound Small are now 210° (instead of 240° in 1996 Study). Small + aircraft follow the same heading as Large Turboprops. Regional Jets have the same procedures as Large Jets A.

Figure 14 shows the ATC procedures required to implement the departure noise restrictions in the East Flow, when departing on runway 10L/10R.

Figure 14. Portland Departure Noise Procedures – East Flow

The following refers to the chart below:

A | B | C | E	Totally Independent with Respect to Noise
B | C | E	Independent of Everyone with Respect to Noise
VFR Flight Plans	No Noise Dependency
A South | A North	Full Noise Dependency
A | D	Noise Dependency to 3,000' (About 4NM from East End of Runway) (Jet/Turbine = 1 minute, Turbine/Jet = 2 minutes)
A | F	Noise Dependency to 3,000' (About 4NM from East End of Runway) (Jet/Turbine = 1 minute, Turbine/Jet = 2 minutes)
D | F	Noise Dependency to 3,000' (About 4NM from East End of Runway) (Jet/Turbine = 1 minute, Turbine/Jet = 2 minutes)



East Flow

To depart 2 dissimilar jets (when the trail aircraft is a smaller jet) going to the same exit fix at the center — controllers must add 30 seconds to trail departure, if they cannot insert a different type of departure. However, they can usually insert a different type of departure, thereby eliminating the need to add the extra separation. *Updated 12/94.*

VFR Flight Plan

Small aircraft can do an immediate turn onto any of several departure paths. *Updated 12/94.*

Notes:

Assume all Biz Jets are quiet because most are quiet.

Headings for Southbound Small are now 170° (instead of 120° in 1996 Study). Small + aircraft follow the same heading as Large Turboprops. Regional Jets have the same procedures as Large Jets A.

Airfield Capacity

The PDX Capacity Team defined airfield capacity to be the maximum number of aircraft operations (landings or takeoffs) that can take place in a given time. The following conditions were considered:

- Airspace constraints.
- Ceiling and visibility conditions.
- Runway layout and use.
- Aircraft mix.
- Percent arrival demand.
- Noise abatement procedures.
- ATC procedures due to departure noise restrictions at PDX.

Figure 10 illustrates the hourly profile of the daily demand for the Baseline activity level of 322,0000 operations per year, the Future 1 activity level of 484,000 operations per year, and the Future 2 activity level of 620,000 operations per year.

Figure 15 represents the airfield capacities for PDX. These values were developed for the East Flow and West Flow configurations, under VFR 1, VFR 2 and IFR 1 conditions, with a 50/50 split of arrivals and departures and balanced hourly flow rates. The capacities were based on PDX 1999 acceptance rates and Future 2 ADSIM flow rates.

A comparison of the information contained in Figures 10 and 14 concludes that:

- The IFR 1 arrival capacity of 40 arrivals for the Basecase scenario is not exceeded at the 1999 activity level.
- The IFR 1 arrival capacity for the Basecase is exceeded during nine hours of the day at Future 1 and 15 hours of the day at Future 2.
- The IFR 1 arrival capacity of 60 arrivals for the New Parallel Runway (with North/South Taxiway and No Departure Restrictions for Any Aircraft) is not exceeded at Future 1 and is exceeded four hours of the day at Future 2.

Figure 15. Airfield Capacity - 50/50 Split and Balanced Hourly Flow Rates

Basecase		
VFR 1	60 arrivals	60 departures
VFR 2	48 arrivals	48 departures
IFR 1	40 arrivals	40 departures
New Parallel Runway *(with North/South Taxiway and No Departure Noise Restrictions for Any Aircraft)*		
VFR 1	70 arrivals	70 departures
VFR 2	64 arrivals	64 departures
IFR 1	60 arrivals	60 departures

Aircraft Delays

Aircraft Delay is defined as the time above the unimpeded travel time for an aircraft to move from its origin to its destination.

The major factors influencing aircraft delays include, but are not limited to:

- Ceiling and visibility conditions.
- Aircraft and ATC system demand.
- Airfield physical characteristics.
- Air traffic control procedures.
- Aircraft operational characteristics.
- Noise abatement procedures.
- ATC procedures due to departure noise restrictions at PDX.

The ADSIM generated average delay in minutes per operation. A description of this model is included in Appendix B.

Summary of Annual Delay Savings

Based on the analysis completed during the study, the Capacity Team identified the following capacity enhancement alternatives:

Figure 16. Annual Delay Savings

		Estimated Annual Delay Savings (in hours and millions of 2000 dollars)	
		Future 1 484,000	**Future 2 620,000**
Airfield and Operational Alternatives			
1, 3, 6	Third Parallel Runway, N/S Taxiway, and No Departure Noise Restrictions for Any Aircraft	$60.1	$645.7
	Savings Over Combined Alternatives 3 and 6	*$14.4*	*$82.8*
	Savings Over Combined Alternatives 4, 3, and 6	*$9.2*	*$48.5*
3, 6	N/S Taxiway and No Departure Noise Restrictions for Any Aircraft	$45.7	$562.9
	Savings Over Alternative 6	*$12.3*	*$91.8*
4, 3, 6	Simultaneous CAT I Approaches to Existing Parallels, N/S Taxiway, and No Departure Noise Restrictions for Any Aircraft	$50.9	$597.1
	Savings Over Alternative 6	*$17.5*	*$126.1*
	Savings Over Combined Alternatives 3 and 6	*$5.2*	*$34.3*
5	No Departure Noise Restrictions for Turboprops and Biz Jets	$28.0	$416.0
6	No Departure Noise Restrictions for Any Aircraft	$33.4	$471.0
	Savings Over Alternative 5	*$5.4*	*$55.0*

Appendix A – Participants

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Airline Pilots Association
Jim Antisdel
Jim Betty

Air Transport Association
Richard Cox

Military

Oregon Air National Guard
LTC Mike Bieniewicz

Appendix B – Computer Model and Methodology

The Portland Capacity Team studied the effects of various alternatives proposed to reduce delay and enhance capacity. The options were evaluated considering the anticipated increase in demand. The analysis was performed using computer-modeling techniques. A brief description of the model and the methodology employed follows.

Computer Model

Airfield Delay Simulation Model (ADSIM)

The Airfield Delay Simulation Model (ADSIM) is a fast-time, discrete event model, which employs stochastic processes and Monte Carlo sampling techniques. It describes the significant movements of aircraft on the airport and the effects of delay in the adjacent airspace, composed of the common approach and departure corridors. The model was validated in 1978 at Chicago O'Hare International Airport against actual flow rates and delay data. It was calibrated for this study against field data collected at PDX to ensure that the model was site specific. PDX was simulated with the short-form of the model, using an abbreviated taxi-structure.

Inputs for the simulation model were derived from empirical field data. The model used a demand profile and fleet mix that contained precise definitions of the characteristics of the aircraft serving PDX. Other key inputs included runway usage, runway occupancy times and exit probabilities, lengths of final common approach and aircraft approach speeds, aircraft separations, gate service times, and ATC rules and procedures. Critical inputs for PDX were the ATC procedures that were required to simulate the departure noise restrictions.

The model repeated each experiment 10 times using Monte Carlo sampling techniques to introduce system variability, which occurs on a daily basis in actual airport operations. The results were averaged to produce the following output statistics: total and hourly aircraft delay; travel times; and flow rates for the airport and individual runways.

Methodology

Model simulations included present and future air traffic control procedures, various airfield alternatives, and air traffic demands for different times. To assess the benefits of proposed airfield alternatives, different airfield configurations were derived from present and projected airport layouts. The projected implementation time for air traffic control procedures and system alternatives determined the aircraft separations used for IFR and VFR weather simulations.

For the delay analysis, agency specialists developed traffic demands based on the *Official Airline Guide (OAG),* historical data, and various forecasts. Aircraft volume, mix, and peaking characteristics were developed for three demand periods: Baseline, Future 1, and Future 2. The estimated annual delays for the proposed alternatives options were calculated from the experimental results. These estimates took into account the yearly variations in runway configurations, weather, and demand based on historical data.

The potential delay reduction for each alternative was assessed by comparing the annual delay estimates with the Basecase.

Appendix C – List of Abbreviations

ADSIM	Airfield Delay Simulation Model
ALP	Airport Layout Plan
ARR	Arrival
ARTCC	Air Route Traffic Control Center
ASC	Office of System Capacity, FAA
ATC	Air Traffic Control
ATCT	Airport Traffic Control Tower
A&D	Arrival and Departure
Biz Jets	Business Jets
CAT	Category – of instrument landing system
DEP	Departure
DME	Distance Measuring Equipment
FAA	Federal Aviation Administration
GA	General Aviation
IFR	Instrument Flight Rules
ILS	Instrument Landing System
IMC	Instrument Meteorological Conditions
NM	Nautical Miles
N/S	North/South
OAG	Official Airline Guide
PDX	Portland International Airport
ROT	Runway Occupancy Time
RWY	Runway
SM	Statue Miles
TWY	Taxiway
TRACON	Terminal Radar Approach Control
VFR	Visual Flight Rules
VMC	Visual Meteorological Conditions